It is well known that diagnostics and treatment of many diseases of the human eye is connected with monitoring of glucose content. However, in spite of numerous investigations dealing with transport of the metabolite within biological tissue the problem of estimating the diffusion coefficient of glucose in ocular tissues has not been studied in detail.

Goal of the study is to measure the diffusion coefficient of glucose in rabbit eye sclera and conjunctiva.

**Materials and methods**

**Experimental setup**

For this study in tens rabbit eye sclera and conjunctiva samples were used. The samples were obtained from autopsy and kept in saline at temperature 4-5°C during 24 hour until spectroscopic measurements.

Measurement of collimated transmittance has been performed using a commercially available spectrometer USB-4000 (Ocean Optics, USA); 4-cuvette with the tissue samples; 3-multichannel spectrometer–halogen lamp HL-2000; 2-fiber delivering light to the sample; 5-fiber collecting light passed through the sample; 4-commercially available 40% aqueous solution of glucose was used. Refractive index of the solution within interstitial fluid, cm²/sec.

**Glucose diffusion coefficient estimation**

Determination of glucose concentration within sclera and conjunctiva has been performed using the assumption:

\[ T = \exp(-\mu_x I) \]

\[ \mu_x = N \pi^2 ax^2 \left( m^2 - 1 \right) \left[ 1 + \frac{2}{(m^2 + 1)} \right] (1-\phi)/(1+\phi) \]

\[ x = 2\pi a r, \quad \mu = n_s/n_t, \quad n_s = n_0 (1-C) + n_C C \]

\( T \) is the collimated transmittance; \( \mu_x \) is the scattering coefficient; \( I \) is the tissue thickness; \( N \) is the numerical concentration of the tissue scatterers; \( a \) is the scatterers radius; \( n_s = 1.411 \) is the refractive index of the scatterers; \( n_t \) is the refractive index of interstitial fluid of the tissue; and \( \phi \) is the volume fraction of the scatterers; \( n_0 = 1.332 \) is the refractive index of interstitial fluid of tissue before glucose diffusion; \( n_t \) is the refractive index of the glucose solution; and \( C \) is the concentration of glucose within tissue.

Penetration of glucose in eye conjunctiva was described in the framework of the free diffusion model

\[ \frac{\partial C(x,t)}{\partial C} = D \frac{\partial^2 C(x,t)}{\partial x^2} \quad \text{Diffusion equation} \]

\[ C(0,t) = C_0 \quad \text{and} \quad C(l,t) = C_0 \quad \text{Boundary conditions} \]

\[ C(x,0) = 0 \quad \text{Initial condition} \]

Solution of the diffusion equation for slab with thickness \( l \) at moment \( t \) with the boundary and the initial conditions has the form

\[ C(t) = C_0 \left( 1 - \frac{8}{\pi^2} \sum_{m=1}^{\infty} \frac{1}{(2m+1)^2} \exp\left(-\left(2m+1\right)^2 \pi^2 D/t^2 \right) \right) \]

\( C(t) \) is the volume-averaged concentration of the glucose within tissue sample, g/ml; \( D \) is diffusion coefficient, cm²/sec.

In a first order approximation, solution of the diffusion equation can be reduced to the form

\[ C(t) = C_0 \left( 1 - \exp\left(-t/\tau\right) \right) \]

\[ \tau = \frac{2}{\pi^2 D} \quad D = p D_s = (1-\phi) D_0 \]

\( \tau \) is diffusion time constant, sec; \( p \) is porosity coefficient of conjunctiva; \( \phi \) is volume fraction of scatterers; and \( D_0 \) is glucose diffusion coefficient within interstitial fluid, cm²/sec.

**Motivation**

**Optical clearing of eye tissues**

**Results**

**Summary**

Obtained results have shown that application of 40%-glucose solution as a clearing agent allows to control by sclera and conjunctiva optic parameters. Thus, an action of the solution is increase of collimated transmittance and decrease of scattering.

This achievement is very important for optical diagnostics approaches.

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**Fig.4.** The time-dependent transmittance of the eye sclera measured at different wavelength concurrently with administration of glucose solution

The average values of glucose diffusion coefficient in rabbit eye conjunctiva and sclera are \((3.2\pm3.9)\times10^{-7}\) and \((9.38\pm6.84)\times10^{-7}\) cm²/sec, respectively.